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Studies of the Rare-Earth Hydrides
Technical Report X

DISCUSSION AND SUMMARY

Office of Naval Research
Physical Sciences Division

Project No. NR 356-290

Contract No. Nonr 228(03)

By
James C. Ward, Project Supervisor
and
William L. Korst, Research Assistant

The Department of Chemistry
University of Southern California
Los Angeles 7, California

June 30, 1956

Title List of Technical Reports on
"Studies of the Rare-Earth Hydrides"

June 30, 1956

Office of Naval Research
Physical Sciences Division

Project No. NR 356-290

Contract No. Nonr 228(03)

by

James C. Warf, Project Supervisor
and

William L. Korst, Research Assistant

The Department of Chemistry
University of Southern California
Los Angeles 7, California

- Technical Report I. A Survey of the Literature concerning the Rare-Earth Hydrides.
- Technical Report II. Dispersions of Rare-Earth Hydrides in Mercury. High-Temperature Thermostatted Furnace. Silica Torsion Balance.
- Technical Report III. Pressure-Temperature-Composition Studies of the Lanthanum-, Cerium-, Praseodymium-, Neodymium-, Samarium-, and Ytterbium-Hydrogen Systems. Experimental.
- Technical Report IV. Pressure-Temperature-Composition Studies of the Lanthanum-, Cerium-, Praseodymium-, Neodymium-, Samarium-, and Ytterbium-Hydrogen Systems. Results.
- Technical Report V. The Crystal Structure of the Deuterides of Ytterbium and Europium.
- Technical Report VI. Solutions of Europium and Ytterbium Metals in Liquid Ammonia
- Technical Report VII. Crystal Structure of the Rare-Earth Metals.
- Technical Report VIII. Crystal Structure of the Rare-Earth Hydrides. X-Ray Diffraction by Rare-Earth Hydride Amalgams.
- Technical Report IX. Lanthanum Monoxide.
- Technical Report X. Discussion and Summary.

DISCUSSION AND SUMMARY

Discussion

The results obtained in the different fields of investigation of the various rare earth metal-hydrogen systems have already been discussed in the individual chapters of this dissertation. Evidence has been presented supporting a plausible explanation of the nature and constitution of the rare earth hydrides. This explanation may at best be called a hypothesis; additional experimental studies, such as magnetic measurements, and measurements of electrical conductivity of hydrides of various compositions, are needed for further elucidation of their constitution.

Summary

A physical chemical investigation of the hydrides of various rare earth metals has been carried out. The principal fields of investigation have been studies of pressure-temperature-composition relationships, and X-ray diffraction studies of the powdered hydrides.

The properties and behavior of the hydrides formed by lanthanum, cerium, praseodymium, and neodymium are very similar. Dissociation pressure isotherms for these systems

consist of three branches: 1) an initial ascending branch at low hydrogen composition, indicative of the solution of hydrogen in the metal to form a single solid phase; 2) a constant-pressure plateau indicating the co-existence of two solid phases; 3) a final, steeply ascending curve extending into the region of higher hydrogen composition. The relative dissociation pressures of the hydrides and deuterides of lanthanum and cerium have been compared and discussed.

X-ray diffraction studies have confirmed the face-centered cubic structures of these hydrides, which are greatly expanded over the structures of the metals. This expansion is a maximum for the hydrogen-rich phase of the two-phase region; with further addition of hydrogen the lattice contracts slightly.

Similarities between the hydrides and the monochalcogenides of these rare earth elements have been pointed out, and the probable nature of the bonding in the hydrides has been discussed.

The properties of dispersions of the hydrides of lanthanum and cerium in mercury have been investigated.

The metals europium and ytterbium have been found to form dihydrides which are isostructural with the hydrides of the alkaline earth metals. These two rare earth metals

have also been found to dissolve in liquid ammonia. Some of the properties of these metal-in-ammonia solutions have been investigated.

The structures of the rare earth metals themselves have also been investigated, and evidence has been found showing that the hexagonal modifications of the metals do not possess a simple hexagonal close-packed structure. Evidence for the existence of lanthanum monoxide has been obtained; indications of similar compounds of other rare earth metals have also been found.

See Technical Report 1 for references.